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Addendum to report on
Elbow River flood control

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May 30, 1987.

Mr. J. L. Reid,
Supervisor Water Control & Development,
Department of Water Resources,
Terrace Building,
100-6 Street & 4th Ave.,
Edmonton, Alberta.

ADDENDUM TO
REPORT ON
ELBOW RIVER FLOOD CONTROL
FOR
DEPARTMENT OF WATER RESOURCES
PROVINCE OF ALBERTA

Dear Mr. Reid:

In our report of January 29, 1987, we recommended various schemes which could be adopted to reduce the risk of flooding to the Elbow River, including the discharge from the Elbow Reservoir to a maximum of 3,000 cfs.

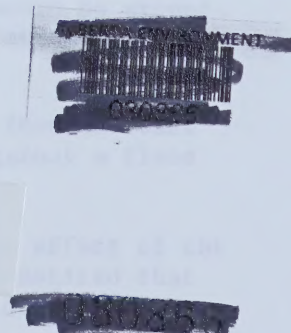
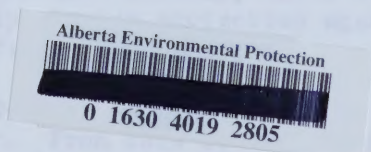
In addition, we recommended that the side dam on the Elbow Reservoir be raised to one of the proposed schemes were approved for flood control.

We recommended that the side dam be raised to 1,000 ft high to a crest elevation of 1,112.7, this being the level of the reservoir required to store a maximum flood of 40,000 cfs.

Unfortunately, we neglected to allow for the Alberta Department of the Environment Library



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May 30, 1967.

Mr. J.L. Reid,
Supervisor Hydro-Electric Development,
Department of Water Resources,
Terrace Building,
106th Street & 96th Ave.,
Edmonton, Alberta.

Elbow River Flood Control
File: AWR 1405-1 ER-200

Dear Mr. Reid:

In our report of January 20, 1967, we recommended various schemes which could be adopted to protect the City of Calgary against flood on the Elbow River, limiting the discharge from the Elbow Reservoir to a maximum of 6,000 cfs.

In addition, we recommended that the side dam on the Elbow Reservoir be raised if none of the recommended schemes were adopted for flood control.

We recommended that the side dam be raised at least 5 feet to a crest elevation of 3512.5, this being the level of the reservoir required to pass a catastrophic flood of 90,000 cfs.

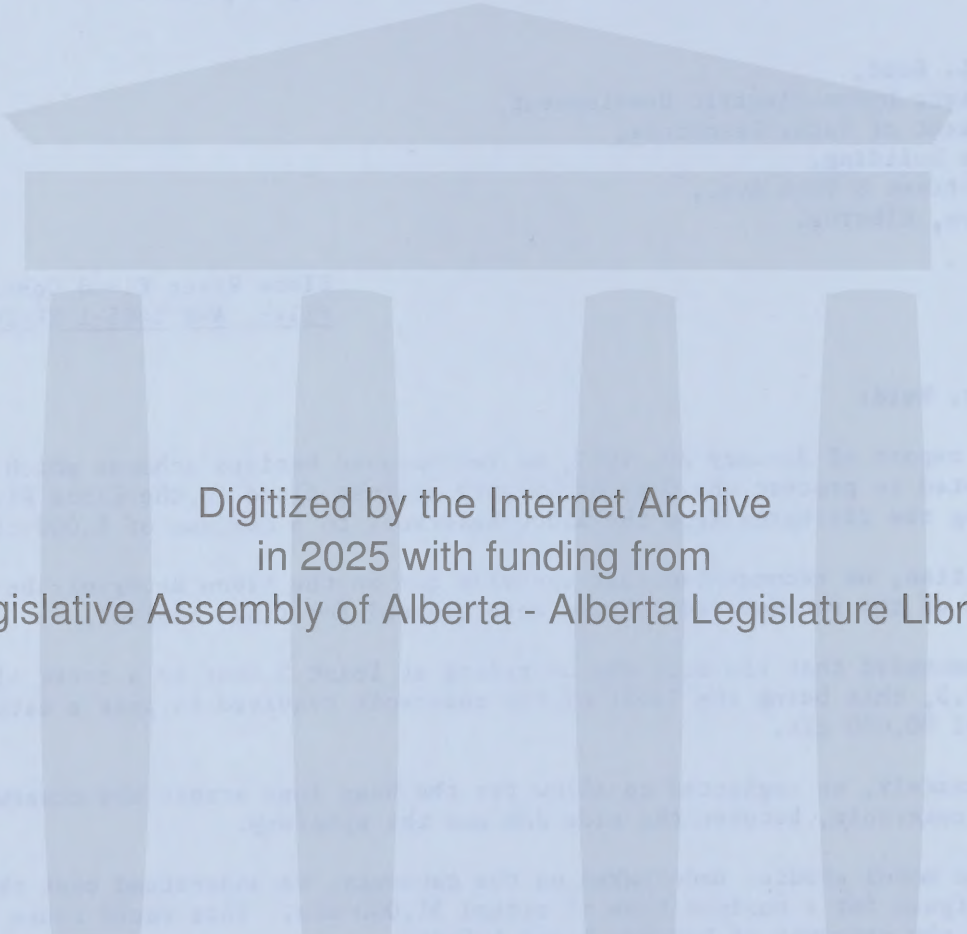
Unfortunately, we neglected to allow for the head loss across the causeway built in the reservoir, between the side dam and the spillway.

From the model studies undertaken on the causeway, we understand that the gap was designed for a maximum flow of around 51,000 cfs. This would cause a head loss at the causeway of between 5 and 6 feet.

A flow of 51,000 cfs from the Glenmore Dam, would require a reservoir elevation of about 3503. Hence the water level upstream of the causeway would be around elevation 3509. Allowing for 3.5 feet of freeboard, this would mean that the crest of the side dam would be at elevation 3512.5.

In other words, due to the head loss across the causeway, the 5 foot increase in the elevation of the side dam will only provide protection against a flood of 51,000 cfs, instead of a catastrophic flood of 90,000 cfs.

We are enclosing two copies of Dwg. No. D-AWR-1013-14 showing the effect of the causeway on water levels in the reservoir. From this it will be noticed that the side dam will be overtopped when the spillway discharge reaches about 59,000 cfs.



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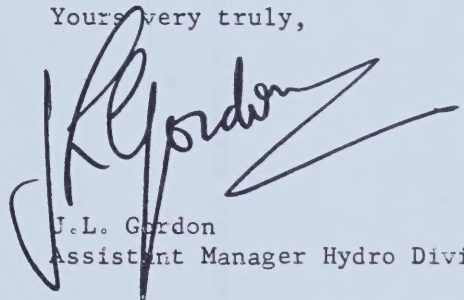
A considerable increase in the elevation of the side dam will be required if protection is to be achieved against a catastrophic flood of 90,000 cfs.

Since the road across the reservoir is at elevation 3513 at the causeway bridge, it is evident that a catastrophic flood would overtop the roadway. Without knowing the exact profile of the roadway, we would suspect that the upstream water levels would rise to around 3518 for a flood through the causeway opening, and across the roadway, totalling 90,000 cfs. This would mean that the crest of the side dam would have to be set at around elevation 3521, in order to provide protection against a catastrophic flood.

This elevation is approximately 9 feet higher than that recommended in our report.

We would appreciate knowing whether this letter will be sufficient to inform you of the changes in our report recommendations, or whether you wish us to issue an addendum to the report.

Yours very truly,

A handwritten signature in dark ink, appearing to read 'J.L. Gordon', with a long, sweeping horizontal stroke extending to the right.

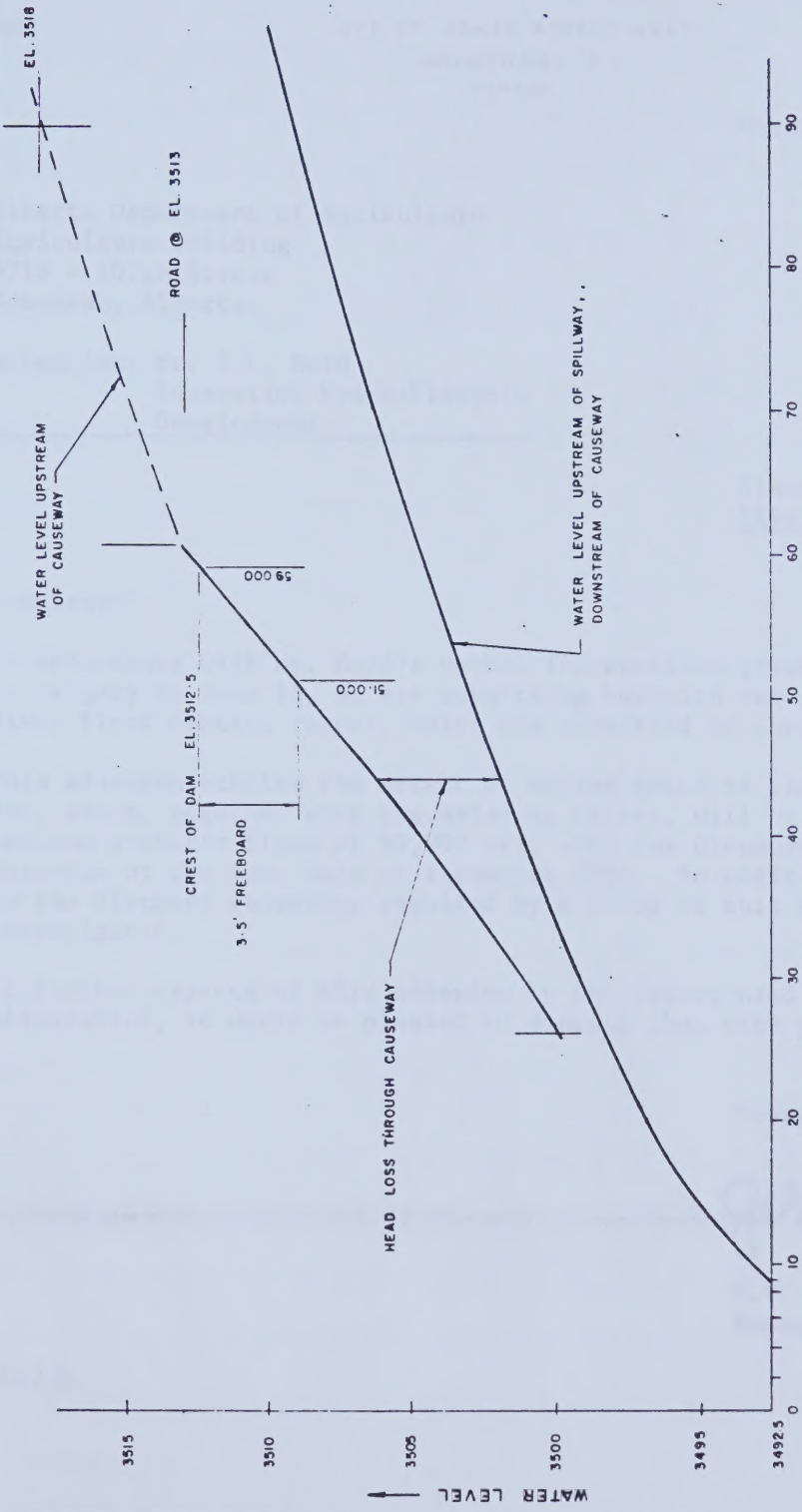
J.L. Gordon
Assistant Manager Hydro Division

JLG/jh
encl.

cc. Mr. G.V. Eckenfelder (encl.)
Mr. K.G. Brittain "
Mr. G.C. Atwell "

P.S. June 23rd, 1967

As requested, your letter of June 21, twenty copies of this letter and drawing are being forwarded for inclusion in report.



SPILLWAY AND VALVE DISCHARGE IN 1000 C.F.S.

MONTREAL ENGINEERING CO. LTD.
DEPARTMENT WATER RESOURCES
PROVINCE OF ALBERTA
ELBOW RIVER REGULATION
GLENMORE RESERVOIR
STAGE DISCHARGE CURVES
DESIGNED: J.L.G. DRAWN: H.H. DATE: MAY '87
SUPERVISOR: <i>[Signature]</i> FILED: <i>[Signature]</i>
W.O. No.: AWR-1403-1 SCALE: <i>[Signature]</i>
DWG. NO.: C-AWR-1013-14

MONTREAL ENGINEERING COMPANY, LIMITED

CORRESPONDENCE:
P.O. BOX 250
PLACE D'ARMES,
MONTREAL 1.

276 ST. JAMES STREET WEST
MONTREAL 1
CANADA

TELEX: 01-20227
CABLES: "MONENCO"
842-8301

October 31st, 1967.

Alberta Department of Agriculture
Agriculture Building
9718 - 107th Street
Edmonton, Alberta.

Attention: Mr. J.L. Reid
Supervisor Hydro-Electric
Development

Elbow River Flood Control
File: AWR 1405-2 BR-200

Gentlemen:

In accordance with Mr. Reid's verbal instructions given at the meeting held in Calgary on June 15, we are submitting herewith our addendum to the Elbow River Flood Control report, which was submitted on January 20, 1967.

This addendum studies the effect of adding gates to the crest of the Glenmore Dam, which, together with the existing valves, will be capable of passing the maximum probable flood of 90,000 cfs, with the Glenmore Reservoir immediately upstream of the dam, held at elevation 3505. In addition, the modifications to the Glenmore causeway, required by a flood of this magnitude are investigated.

If further aspects of this addendum to the report need clarification or elaboration, we would be pleased to discuss them with you.

Yours very truly,



G.V. Eckenfelder
Manager Hydro Division

JLG/jh

SCOPE OF REPORT ADDENDUM

As presently constructed, the Glenmore Dam has a simple overflow spillway, with the crest set at elevation 3492.5. During a large flood, the water level in Glenmore Reservoir could rise to several feet above the spillway crest elevation.

The January 20, 1967 report recommended that the spillway crest be raised to elevation 3505.0, to provide protection against a 1 in 45 year flood. During a catastrophic flood, the water level in the reservoir would rise by several feet above the spillway crest elevation.

Certain physical characteristics of the site establish a maximum elevation for the Glenmore Reservoir. For reasons related to property development, the City of Calgary does not wish to raise the side dam, constructed with a crest elevation at 3512.5, hence the water level, allowing 3 feet of freeboard, upstream of this side dam can be set at elevation 3509.5. A causeway across the Glenmore Reservoir, constitutes a restriction to the passage of large floods. Allowing a maximum of 4.5 feet head loss across this causeway, with the maximum flood, means that the maximum elevation of the reservoir immediately upstream of the Glenmore Dam will be 3505.0.

In order to obtain the benefits to be derived from an increase in flood storage, without the objections of the main reservoir rising above elevation 3509.5, this Report Addendum is confined to an investigation of the cost of constructing a gated spillway, having sufficient gates with the two valves to pass a 90,000 cfs flood, with the reservoir held at elevation 3505.0 downstream of the causeway.

FINDINGS

1. Glenmore Dam

By constructing a central pier in each of the seven ogee openings, and encasing the existing piers in concrete, 14 gates can be added to the dam. Mass concrete would be used to raise the elevation of the non-overflow section, permitting an increase in full supply level from El. 3492.5 to El. 3505.0

Estimated cost is \$2,500,000.

Alternatively, the same requirements can be met by the installation of 7 long shallow gates, eliminating the central pier.

Estimated cost is \$2,200,000.

The foregoing costs do not include any of the costs associated with the modifications required on the Glenmore causeway.

2. Glenmore Causeway

This causeway was originally designed for a flood of 51,000 cfs.

In order to pass a flood of 90,000 cfs, or almost double the original design, the flow area through the causeway will have to be doubled.

RECOMMENDATIONS

1. To provide flood protection against a 1 in 45 year flood, raise the full supply level of the Glenmore Dam and install 7 spillway gates.
2. In order to provide sufficient flow area for a catastrophic 90,000 cfs flood, without overtopping the Glenmore side dam, double the flow area through the Glenmore causeway.

The foregoing recommendations should be undertaken concurrently.

3. Additional flood protection, or equivalent flood protection can be obtained by constructing the storage dam at the Mitchell site, upstream, as recommended in the January 20, 1967 report.

I N D E X

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1. Raising Glenmore Dam Scheme 5

The required discharge capacity of 90,000 cfs, at reservoir elevation 3505.0, can be provided by the installation of 14 gates, each having a width of 28 feet, and a height of 15.5 feet.

The gates would be constructed on the upstream face of the dam, as shown on Plate 15 & 16. This would not interfere with the four-lane bridge which the City is considering constructing on Glenmore Dam above the present roadway.

Mid-way between each existing pier which presently supports the roadway on the Glenmore Dam, a central pier would be constructed which would contain the guides for a gate on either side. Similarly, the existing piers would be encased in new concrete, cantilevered upstream, which would contain guides for the gates.

The crest of the ogees between the piers, would be modified with reinforced concrete, as shown on Plate 15.

The gates would be standard single leaf fixed wheel gates, four of which would be provided with heating so as to be capable of being operated under severe weather conditions. Each gate would be equipped with twin screw stem hoists attached to each end of the gate, with a cross shaft and central drive unit mounted on a light steel bridge and walkway structure. Provision would be made for dogging the gates in the raised position and for carrying out all normal maintenance and repairs of the gate and hoist in situ. Complete removal of the gate from the slot would require dismantling of the hoist and steel bridge, and the use of mobile cranes.

Operation of the gates would be by push button from a control panel located in the valve control house of the dam, or in the filtration plant, as preferred.

Since gates are being used to raise the water level at the dam, instead of adding mass concrete to the dam, the factor of safety against overturning, and against sliding, will be somewhat lower than in the original design, as illustrated by the following table: (calculated for the overflow section of the dam).

<u>Description</u>	<u>Sliding Factor</u>	<u>Factor of Safety Against Overturning</u>	<u>Distance of Resultant within middle 1/3</u>
Present Dam FSL 3492.5'	0.51	2.16	8.3'
Scheme 1. Report FSL 3505.0'	0.47	2.48	8.9'
Scheme 5. Report FSL 3505.0'	0.65	1.75	4.6'

1. Raising Glenmore Dam Scheme 5 (Cont'd)

However, these factors are still well within the normally accepted limits for dam construction in the North American Continent.

On either side of the gated spillway section, the concrete sections would be build up with mass concrete.

The estimated cost is as follows:

<u>Item</u>	<u>Estimated Cost</u>
Modification of existing ogee.	\$ 870,000
Modification of non-overflow section	45,000
14-crest gates	1,050,000
Sub-total Civil Works	<u>\$1,965,000</u>
Undistributed construction expense	200,000
Special contingency	60,000
Engineering	160,000
Interest during construction	115,000
Sub-total Overhead Cost	<u>\$ 535,000</u>
TOTAL PROJECT COST	<u><u>\$2,500,000</u></u>

2. Raising Glenmore Dam Scheme 6

An alternative to Scheme 5, would be the use of seven long spillway gates, which would span between the existing piers, These gates would have a length of 63 feet, and a depth of 14 feet. As for Scheme 5, they would consist of single leaf fixed wheel gates with essentially similar hoisting systems, as shown on Plate 17.

The details are very similar to that for Scheme 5, except that the central pier is eliminated, thereby not disturbing the pleasing appearance of the existing structure and at the same time increasing the discharge length, which in turn permits a reduction in the height of the gate. (See Plate 15). Two of the gates would be heated, suitable for operation during winter conditions. The factors of safety against sliding and overturning for this arrangement are almost the same as shown for Scheme 5 and they are well within the normally accepted limits.

2. Raising Glenmore Dam Scheme 6 (Cont'd)

The cost has been estimated as follows:

<u>Item</u>	<u>Estimated Cost</u>
Modification of existing ogee	\$ 820,000
Modification of non-overflow section	45,000
7-crest gates	870,000
Sub-total Civil Works	<u>\$1,735,000</u>
Undistributed construction expense	170,000
Special contingency	60,000
Engineering	140,000
Interest during construction	95,000
Sub-total Overhead Cost	<u>\$ 465,000</u>
TOTAL PROJECT COST	<u><u>\$2,200,000</u></u>

Several other alternative arrangements were investigated, using two travelling gantry hoists instead of individual hoists on each gate. This arrangement would offer marginal savings and at the same time would facilitate easier handling and complete removal of the gates for maintenance and repair, however for operating the gates, operators would be required and the time of opening all gates would be considerably extended. A review of the hydrograph of a flood on this river indicates that the time available in which to raise the gates is extremely limited, hence individual hoists, with push button control of each gate appears absolutely necessary.

3. Glenmore Causeway

The Glenmore causeway was originally designed to pass a flood of 51,000 cfs, with a water level difference across the causeway of 5.5 feet.

3. Glenmore Causeway (Cont'd)

As a result of the recent flood studies, the maximum catastrophic flood has now been estimated at 90,000 cfs. In order to avoid exceeding an upstream water level set at elevation 3509.5, it is estimated that the flow area through the causeway must be doubled.

This can be provided by either building a second bridge, similar to the existing bridge, or by providing the equivalent flow area by means of culverts through the causeway fill.

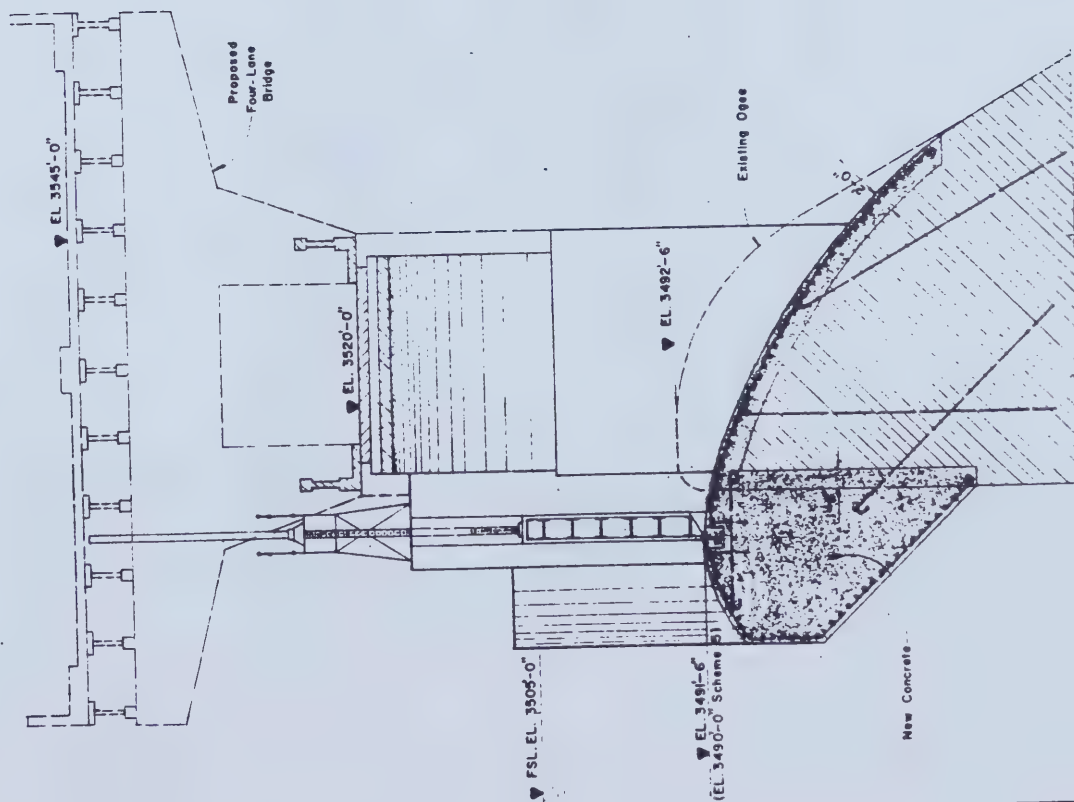
The cost of this work has not been estimated, and has not been included in Schemes 5 or 6.

4. Conclusions

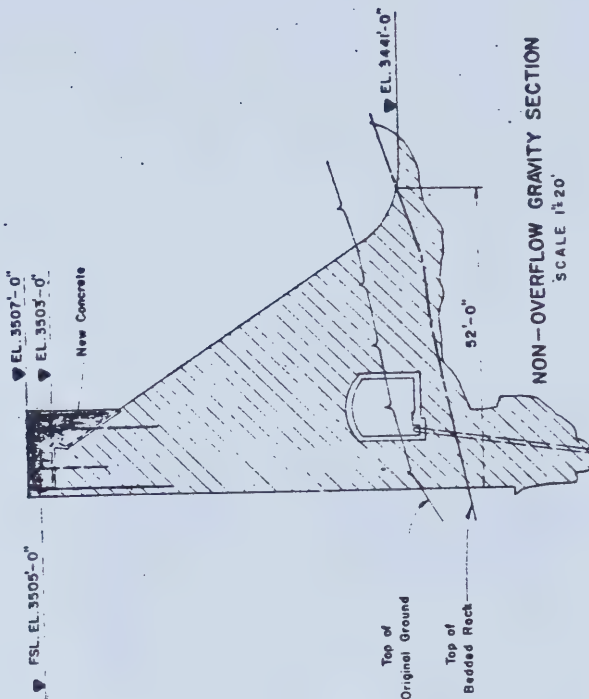
As stated in our report of January 20, 1967, raising of the Glenmore Reservoir to full supply elevation 3505.0, will, in itself, provide flood control sufficient to contain a 1 in 45 year flood, within the reservoir, without exceeding a maximum discharge of 6,000 cfs from the reservoir.

Schemes 5 and 6 will provide the same degree of flood control, with the added benefit of not exceeding a maximum reservoir elevation of 3505.0 upstream of the dam, and 3509.5 upstream of the causeway (provided the causeway flow area is enlarged) with the maximum catastrophic flood of 90,000 cfs.

The cost of Schemes 5 and 6 are comparable with Scheme 1 in the original report, the only minor disadvantage being a reduction in the factor of safety against overturning and sliding for the dam structure.

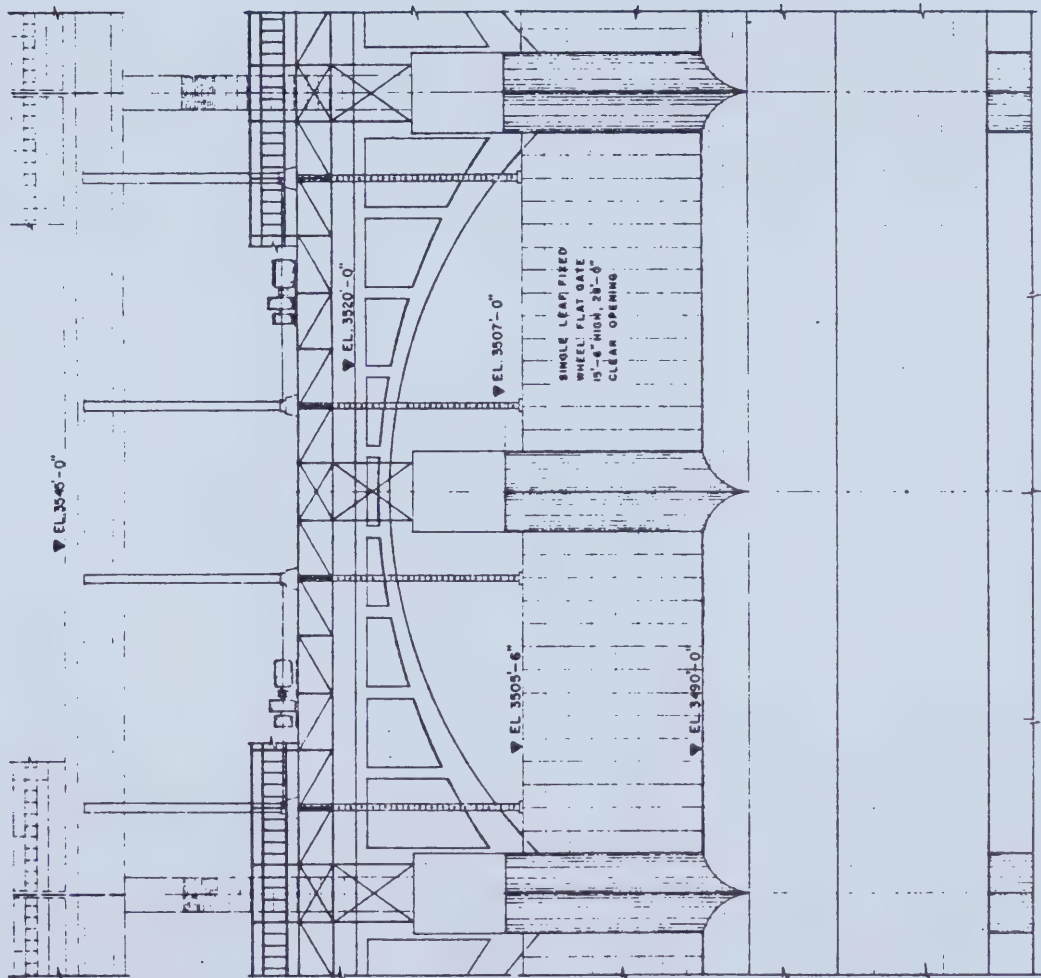


SCHEME 6
SCALE 1" = 10'



NON-OVERFLOW GRAVITY SECTION

MONTREAL ENGINEERING CO. LTD.
DEPARTMENT WATER RESOURCES PROVINCE OF ALBERTA
ELBOW RIVER REGULATION
GLENMORE DAM MODIFICATIONS SCHEMES 5 B-6 — SECTIONS
DESIGNED: <i>P.M.</i> DRAWN: A. M. DATE: OCT 1967
SUPERVISOR: <i>af</i> PASSED: <i>g. h. Campbell</i>
W. O. No.: AWR-1405-2 SCALE: NOTED
DWG. NO.: C-AWR-1013-15



ELEVATION - SCHEME - 5
SCALE: 1" = 10'

MONTREAL ENGINEERING CO. LTD.

DEPARTMENT WATER RESOURCES

PROVINCE OF ALBERTA

ELBOW RIVER REGULATION

GLENMORE DAM MODIFICATIONS

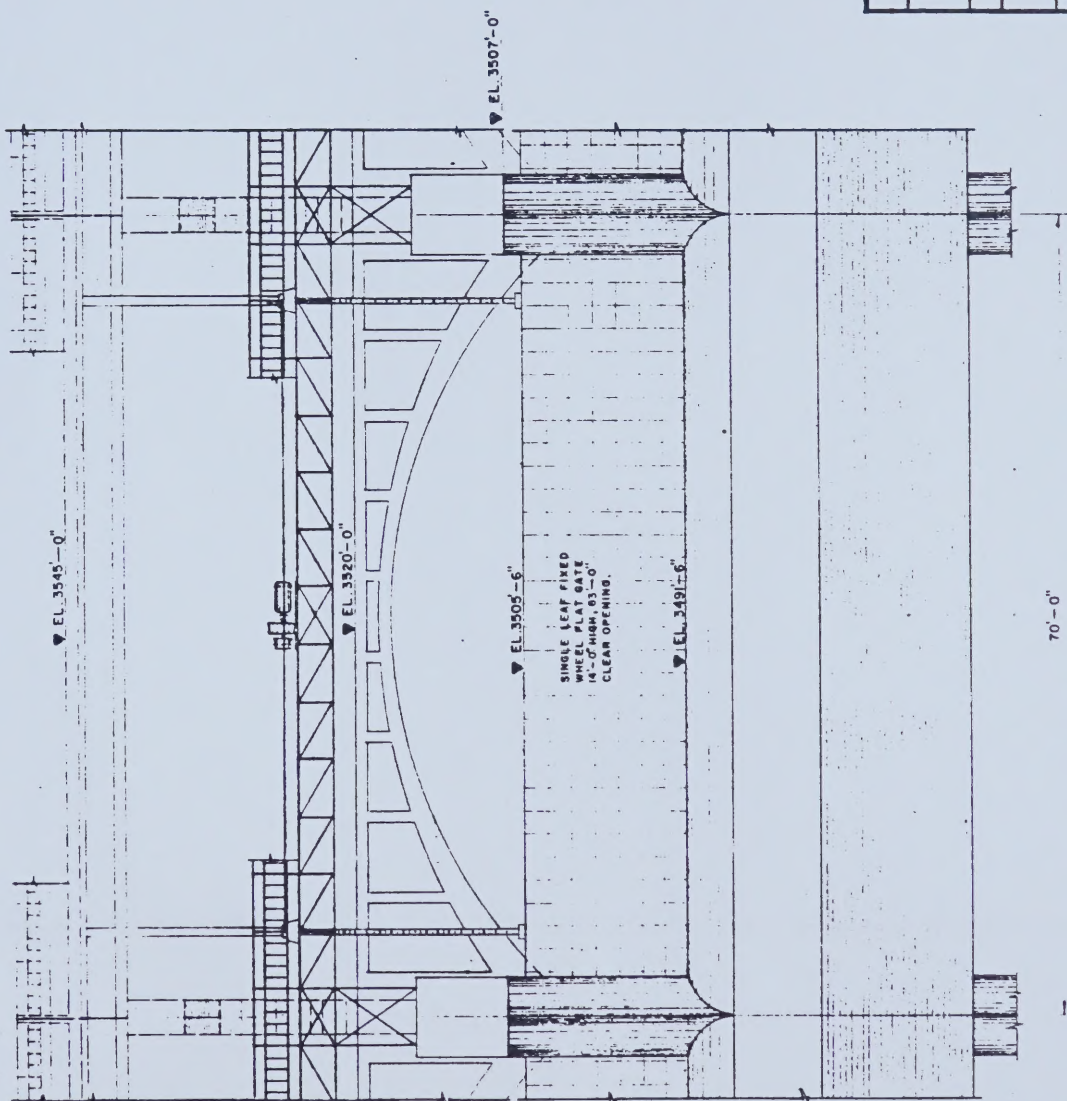
SCHEME - 5 - ELEVATION

DESIGNED: P.H.H. DRAWN: A.M. DATE: OCT. 1967

SUPERVISOR: J. PASSED: J.P. [Signature]

W.O. No.: AWR-1405-2 SCALE: NOTED

DWG. NO.: C-AWR-1013-16



ELEVATION — SCHEME-6
SCALE 1/2" = 10'

MONTREAL ENGINEERING CO. LTD.

DEPARTMENT WATER RESOURCES

PROVINCE OF ALBERTA

ELBOW RIVER REGULATION

GLENMORE DAM MODIFICATIONS

SCHEME 6 — ELEVATION

DESIGNED: P.V. DRAWN: A.M. DATE: OCT. 1967

SUPERVISOR: *H.* PASSED: *W.C. Campbell*

W. O. No.: AWR-1405-2 SCALE: NOTED

DWG. NO.: C-AWR-1013-17

